REMARKS

Claims 19-27 and 29-31 are pending in this application. Claim 18 is cancelled. No claims are amended.

The Rejection of Claim 18

The rejection is rendered moot by cancellation of claim 18.

Rejection of Claim 26

Claim 26 is rejected under 35 U.S.C. 102(e) as allegedly anticipated by or, in the alternative, under 35 U.S.C. 103(a) as allegedly obvious over Prakash *et al.* (U.S. Pat. 6,444,343 B1). The Office Action alleges that claim 26 recites a product-by-process limitation: applying and bonding of a catalyst ink. The Office Action alleges that these process limitations are not given patentable weight as the limitations do not give breadth or scope to the product claim. It is urged that the claimed product allegedly appears to be the same or similar to the prior art product insofar as being a fuel cell comprising a catalyzed membrane electrode assembly with a PSSA-PVDF membrane. It is further urged by the Office Action that any differences that can be shown by the product of the product-by-process claims, would have been obvious to the skilled artisan as a routine modification of the product absent unexpected results. These

contentions, and the rejection as a whole, is respectfully traversed.

The disclosure and teachings of U.S. Patent No. 6,444,343

U.S. Patent No. 6,444,343 discloses and teaches fabrication of membrane electrode assemblies prepared by heat-pressing the polymer electrolyte membrane sample, in its hydrated state, with catalyzed teflon-impregnated porous carbon electrodes to form a single component. The reference discloses and teaches that the preparation of catalyst electrodes is achieved by preparing a paste of electrocatalyst, Nafion® H (5% by weight solution dispersed in lower alcohols) and an aqueous solution of fluorinated polyethylene (PTFE). It is further described that the paste is either applied to PTFE-treated porous carbon paper or directly deposited on the PSSA-PVDF membranes.

Differences between claim 26 and the disclosure and teachings of the cited reference

The ink disclosed and taught in the reference contains NAFION®. As described in the attached Product Information sheet from DuPont™, NAFION® is a copolymer of persulfonic acid and polytetrafluoroethylene. NAFION® does not contain polyvinylidene fluoride (PVDF). The catalyst ink disclosed and taught in the reference contains an electrocatalyst, NAFION® (a

copolymer of persulfonic acid and polytetrafluoroethylene - 5% by weight solution dispersed in lower alcohols) and an aqueous solution of fluorinated polyethylene (PTFE). The ink disclosed and taught in the reference does not contain polyvinylidene fluoride (PVDF).

Rebuttal to the Rejection Under 35 U.S.C. §102(e)

Claim 26 is directed to a fuel cell containing a membrane electrode assembly, wherein the membrane electrode assembly is made by the process of: providing a catalyst ink containing a catalytic material, and poly(vinylidene fluoride); applying the catalyst ink to at least one side of a PSSA-PVDF membrane; and bonding the membrane to at least one electrode. As discussed above, U.S. Patent No. 6,444,343 discloses catalyst electrodes prepared using electrocatalyst, Nafion® H (5% by weight solution dispersed in lower alcohols) and an aqueous solution of fluorinated polyethylene (PTFE) applied to PTFE-treated porous carbon paper or directly deposited on the PSSA-PVDF membranes. The reference does not disclose a catalyst ink containing polyvinylidene fluoride (PVDF).

Thus, U.S. Patent No. 6,444,343 does not disclose every element of the claimed fuel cell containing a membrane electrode assembly, wherein the membrane electrode assembly is made by the

process of: providing a catalyst ink containing a catalytic material, and poly(vinylidene fluoride); applying the catalyst ink to at least one side of a PSSA-PVDF membrane; and bonding the membrane to at least one electrode. Therefore, the reference does not anticipate the fuel cell of claim 26.

Rebuttal to the Rejection Under 35 U.S.C. §103(a)

Applicant respectfully submits that U.S. Patent No. 6,444,343 does not teach or suggest applying a catalyst ink containing a catalytic material, and poly(vinylidene fluoride) to at least one side of a PSSA-PVDF membrane and bonding the membrane to at least one electrode. The reference does not teach or suggest the catalyst ink containing a catalytic material, and poly(vinylidene fluoride).

As discussed above, the reference teaches that the catalyst electrode is prepared using a paste of electrocatalyst, Nafion® H (5% by weight solution dispersed in lower alcohols) and an aqueous solution of fluorinated polyethylene (PTFE) and applying the paste to PTFE-treated porous carbon paper or directly deposited on the PSSA-PVDF membranes. It does not teach the catalyst ink containing a catalytic material, and poly(vinylidene fluoride) as required in the instantly claimed fuel cell. Nowhere does the cited reference suggest adding PVDF

not only to the membrane, but also to the ink that is used to apply on the membrane. Absent such teaching or suggestion, it would not be obvious to one of skill in the art to apply a catalyst ink to a PSSA-PVDF membrane. The suggestion that it would be so obvious is entirely based on hindsight. Applicant respectfully requests reconsideration and withdrawal of the rejection.

Rejection of Claims 19, 20 and 25-27 under 35 U.S.C. §103(a)

Claims 19, 20 and 25-27 are rejected under 35 U.S.C. §103(a) as being unpatentable over Grot *et al.* (U.S. patent no. 5,919,583) in view of Fleisher *et al.* (U.S. patent no. 5,643,689). The Office Action alleges that Grot *et al.* teach a Pt catalyst ink material for a fuel cell, with a binder disclosed as being preferably the same polymer as in the membrane. It is further alleged that Fleisher *et al.* teach a membrane having a polivinylidene fluoride polymer. The Office Action urges that the skilled artisan would find it obvious to employ the same polymer as a binder so as to remain consistent with Grot *et al.*'s disclosure. The Office Action notes that Grot *et al.* do not explicitly teach a PSSA-PVDF membrane. However, it alleged that Fleisher *et al.* teach a matrix polymer,

such as polyvinylidene fluoride (PVDF), together with a second polymer such as sulfonated polystyrenes. The Office Action alleges that this membrane is readable on the claimed PSSA-PVDF membrane combination. Therefore, the Office Action concludes that a skilled artisan would find it obvious to employ this membrane in Grot *et al.'s* disclosure for reasons such as improved electrical contact of the membrane within the formed membrane/electrode assembly. Applicant disagrees.

The teachings of Grot *et al.*

Grot *et al.* teach a polymer membrane for use in a membrane electrode assembly. The reference teaches that a catalyst layer may be formed on the membrane as a film of a polymer which serves as a binder for the catalyst particles. It is taught that the binder polymer is a polymer having cation exchange groups and most preferably is the same polymer as in the membrane. The reference provides example, in an MEA, of a perfluorinated sulfonic acid polymer membrane and a platinum catalyst, where the binder polymer can also be perfluorinated sulfonic acid polymer and the catalyst can be a platinum catalyst supported on carbon particles. The reference does not teach a catalyst ink containing a catalytic material and

poly(vinylidene fluoride). Nor does it teach or suggest the PVDF-PSSA membrane used in the instant claims.

The teachings of Fleisher *et al*.

Fleisher *et al*. teach non-liquid proton conductor membranes, i.e., solid polymer proton conducting substrates, for use in electrochemical systems. The membranes that are taught in the reference swell when contacted with a selected solvent. Fleisher *et al*. teach that the membrane contains matrix polymer such as polyvinylidene fluoride, polyhydroxyethylene, polyethyleneimine, polyacrylic acid, polyethylene oxide, poly-2-ethyl-2-oxazoline, phenol formaldehyde resins, polyacrylamide, poly-N-substitued acrylamide, poly-4-vinylpyridine, polymethacrylic acid, poly-N-vinylimidazole, polyvinyl sulfonic acid, poly-2-vinylpyridine, polyvinylpyrrolidone, polyvinylphosphonic acid, a polymer having a hydrophilic functional moiety, agar, agarose, polyvinyl alcohol and mixtures thereof. The reference further teaches that the matrix polymer is dissolved in a first solvent with an acidic multimer to form a homogeneous mixture. The mixture is then dried to obtain non-liquid proton conductor membrane. Fleisher *et al*. do not teach or suggest PVDF-PSSA membrane of the instant claims.

Analysis

It is respectfully submitted that the rejection has failed to set forth a case of *prima facie* obviousness because the combination of teachings of Grot *et al.* with the teachings of Fleisher *et al.* does not result in the instantly claimed process for making a membrane electrode assembly for a fuel cell, by providing a catalyst ink containing a catalytic material, and poly(vinylidene fluoride); applying the catalyst ink to at least one side of a PSSA-PVDF membrane; and bonding the membrane to at least one electrode.

Grot *et al.* do not teach or suggest a catalyst ink containing a catalytic material and poly(vinylidene fluoride), nor does it teach or suggest the use thereof with a PVDF-PSSA membrane as claimed in the instant process. Fleisher *et al.* do not cure this deficiency in teachings of Grot *et al.* As discussed above, the membrane taught in Fleisher *et al.* is obtained by dissolving matrix polymer in a solvent with an acidic multimer to form a homogeneous mixture and drying the mixture. Applicant respectfully submits that the membranes taught in Fleisher *et al.* are different than PVDF-PSSA membrane of the instant claims. The PVDF-PSSA membrane contains polystyrene sulfonic acid crosslinked within a poly(vinylidene

fluoride) matrix. Such membranes are known in the art, for example, U.S. Patent No. 6,444,343 describes this membrane in detail.

Thus, neither the catalyst ink nor the PVDF-PSSA membrane of the instant claims is taught by the combination of teachings of the references. Therefore, the rejection has failed to set forth a *prima facie* case of obviousness.

Rejection of Claims 21, 22, 23, 24, 29, 30 and 31 under 35 U.S.C. §103(a)

Claims 21, 22, 29 and 30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Grot *et al.* in view of Fleisher *et al.* as applied for claims 19, 20 and 25-27, and further in view of Cabasso *et al.* (U.S. Pat. 5,783,325). Claim 23 is rejected under 35 U.S.C. 103(a) as being unpatentable over Grot *et al.* in view of Fleisher *et al.* as applied for claims 19, above, and further in view of Kindler (U.S. Pat. 5,992,008). Claims 24 and 31 are rejected under 35 U.S.C. 103(a) as being unpatentable over Grot *et al.* in view of Fleisher *et al.* as applied for claims 19, 20 and 25-27 above, and further in view of Lawrance *et al.* Applicant disagrees.

Claims 21, 22, 23, 24, 29, 30 and 31 are dependent claims that depend from claims 19 and 27 and further define that the

catalyst ink and the membrane used in the independent claims. As discussed above, the combination of teachings of Grot *et al.* and Fleisher *et al.* does not teach or suggest applying a catalyst ink containing a catalytic material and PVDF onto a PVDF-PSSA membrane as claimed in the instant processes of independent claims 19 and 27, from which claims 21, 22, 23, 24, 29, 30 and 31 depend. The tertiary references, however, do not remedy the deficiencies of Grot *et al.* and Fleisher *et al.* Furthermore, since Grot *et al.* and Fleisher *et al.* fail to describe the subject matter of the independent claims from which these claims depend, the rejection of the dependent claims must fail as well. No further argument based upon the additionally cited references is needed. Accordingly, applicant requests reconsideration and withdrawal of the rejections.

Enclosed is a check in the amount of $510 to cover the fee for a three month extension of time. Please apply any other charges or credits to deposit account 06-1050.

Respectfully submitted,

Date: July 11, 2005

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10512272.doc

Attachment: 4-pg. Reference: Product Information sheet from DuPont™, NAFION®

OIPE JC65
JUL 13 2005
PATENT & TRADEMARK OFFICE

Product Information

DuPont™ Nafion® PFSA Membranes

N-112, NE-1135, N-115, N-117, NE-1110

perfluorosulfonic acid polymer

Membranes

Description

DuPont™ Nafion® PFSA membranes are non-reinforced films based on Nafion® PFSA polymer, a perfluorosulfonic acid/PTFE copolymer in the acid (H^+) form. Nafion® PFSA membranes are widely used for Proton Exchange Membrane (PEM) fuel cells and water electrolyzers. The membrane performs as a separator and solid electrolyte in a variety of electrochemical cells that require the membrane to selectively transport cations across the cell junction. The polymer is chemically resistant and durable.

Order and Packaging Information

Membrane dimensions are based on dry product conditioned at 23 °C and 50% Relative Humidity before cutting. The membrane's water content will affect its dimensions, and the change may not be symmetrical in the length, width, and thickness directions. In addition, certain conditioning steps performed by the customer also may affect the dimensions. Customers may wish to review their membrane treatment steps and dimensional requirements with a Nafion® Technical Representative before establishing membrane shipping dimensions.

Standard dry product dimensions for individual pieces include:

- Width: 0.30 m (min.) to 1.22 m (max.)
- Length: 0.30 m (min.) to 1.22 m (max.)

The membrane delivery package for cut pieces will depend on the size and quantity of the membrane order. Smaller-sized membranes are shipped flat, while longer lengths of individual pieces are shipped on a roll. The membranes are protected with a polyethylene wrap and inner packaging, then placed in shipping containers.

Standard dry product dimensions for roll goods include:

- Width: 12-in (0.305-m) and 24-in (0.610-m) standard roll widths, and roll widths from 0.20-m (min.) up to 1.22-m (max.) on special order. Intermediate widths available in increments of 0.125-in.
- Length: 50-meter standard roll length

There is a 100 m^2 minimum order requirement for non-standard roll widths and lengths. Membrane pieces or rolls can be cut to custom sizes, and special packaging provided at additional cost and/or delivery time. Please contact Nafion® Customer Service for details.

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Properties of Nafion® PFSA Membrane

A. Thickness and Basis Weight Properties[1]

Membrane Type	Typical Thickness (microns)	Basis Weight (g/m^2)
N-112	51	100
NE-1135	89	190
N-115	127	250
N-117	183	360
NE-1110	254	500

B. Physical and Other Properties

Property[2]	Typical Value	Test Method
Physical Properties		
Tensile Modulus, MPa (kpsi)		
50% RH, 23 °C	249 (36)	ASTM D 882
water soaked, 23 °C	114 (16)	ASTM D 882
water soaked, 100 °C	64 (9.4)	ASTM D 882
Tensile Strength, maximum, MPa (kpsi)		
50% RH, 23 °C	43 (6.2) in MD, 32 (4.6) in TD	ASTM D 882
water soaked, 23 °C	34 (4.9) in MD, 26 (3.8) in TD	ASTM D 882
water soaked, 100 °C	25 (3.6) in MD, 24 (3.5) in TD	ASTM D 882
Elongation at Break, %		
50% RH, 23 °C	225 in MD, 310 in TD	ASTM D 882
water soaked, 23 °C	200 in MD, 275 in TD	ASTM D 882
water soaked, 100 °C	180 in MD, 240 in TD	ASTM D 882
Tear Resistance - Initial, g/mm		
50% RH, 23 °C	6000 in MD, TD	ASTM D 1004
water soaked, 23 °C	3500 in MD, TD	ASTM D 1004
water soaked, 100 °C	3000 in MD, TD	ASTM D 1004
Tear Resistance[3] - Propagating, g/mm		
50% RH, 23 °C	>100 in MD, >150 in TD	ASTM D 1922
water soaked, 23 °C	92 in MD, 104 in TD	ASTM D 1922
water soaked, 100 °C	74 in MD, 85 in TD	ASTM D 1922
Specific Gravity	1.98	—
Other Properties		
Conductivity, S/cm	0.083	see footnote[4]
Acid Capacity, meq/g	0.89	see footnote[5]

[1] Measurements taken with membrane conditioned to 23 °C, 50% relative humidity (RH).

[2] Where specified, MD - machine direction, TD - transverse direction. Conditioning state of membrane given. Measurements taken at 23 °C, 50% RH.

[3] Tear resistance (g/mm) of dry membrane increases with thickness. Values given are typical for 0.05 mm membrane.

[4] Conductivity measurement as described by Zawodzinski, et.al, *J. Phys. Chem.*, 95 (15), 6040 (1991). Membrane conditioned in 100 °C water for 1 hour. Measurement cell submersed in 25 °C D.I. water during experiment. Membrane impedance (real) taken at zero imaginary impedance.

[5] A base titration procedure measures the equivalents of sulfonic acid in the polymer, and uses the measurement to calculate the acid capacity or equivalent weight of the membrane.

C. Hydrolytic Properties

Property	Typical Value	Test Method
Hydrolytic Properties		
Water content, % water[6]	5	ASTM D 570
Water uptake, % water[8]	38	ASTM D 570
Thickness change, % increase		
from 50% RH, 23 °C to water soaked, 23 °C	10	ASTM D 756
from 50% RH, 23 °C to water soaked, 100 °C	14	ASTM D 756
Linear expansion, % increase[9]		
from 50% RH, 23 °C to water soaked, 23 °C	10	ASTM D 756
from 50% RH, 23 °C to water soaked, 100 °C	15	ASTM D 756

[7] Water content of membrane conditioned to 23 °C, 50% relative humidity (RH), compared to dry weight basis.
[8] Water uptake from dry membrane to water soaked at 100 °C for 1 hour (dry weight basis).
[9] Typical MD and TD values. MD expansion is slightly less than TD.

Recommended Roll Storage Conditions

Unopened roll packages of Nafion® PFSA membrane should be stored in the original shipping box, out of direct sunlight, and in a climate-controlled environment, maintained at 10 to 30°C, and 30 to 70% relative humidity. Before opening the package, pre-condition the membrane roll to the processing area temperature for 24 hours.

Once opened and exposed to the environment, the membrane will equilibrate to the ambient relative humidity, and change in dimensions accordingly. Membrane order dimensions are specified and measured at 23°C and 50% Relative Humidity.

Handling Practices

Ventilation should be provided for safe handling and processing of Nafion® PFSA membrane. The amount of local exhaust necessary for processing Nafion® PFSA membrane at elevated temperatures will depend on the combined factors of membrane quantity, temperature, and exposure time.

Scrap Disposal

Preferred disposal options are (1) recycling and (2) landfill. Incinerate only if incinerator is capable of scrubbing-out hydrogen fluoride and other acidic combustion products. Treatment, storage, transportation, and disposal must be in accordance with applicable federal, state/provincial and local regulations.

Safe Handling and Use of Nafion® PFSA Membranes

The following information should be reviewed before handling and processing Nafion® PFSA Membranes:

- DuPont Material Safety Data Sheet for Nafion® PFSA Membranes N-112, NE-1135, N-115, N-117 and N-1110
- Nafion® Technical Information "Safe Handling and Use"
- "Guide to Safe Handling of Fluoropolymer Resins", Third Edition, June 1998, Published by the Fluoropolymers Division of the Society of the Plastics Industry, Inc.

For more information about Nafion® contact:

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Nafion® Global Customer Service
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Fayetteville, NC 28306, U.S.A.

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The data listed here fall within the normal range of product properties, but they should not be used to establish specification limits nor used alone as the basis of design. This information is based on technical data that DuPont believes to be reliable. It is intended for use by persons having technical skill and at their own discretion and risk. This information is given with the understanding that those using it will satisfy themselves that their particular conditions of use present no health or safety hazards. Because conditions of product use are outside our control, DuPont makes no warranties, express or implied, and assumes no obligation or liability in connection with any use of this information or for results obtained in reliance thereon. The disclosure of the information is not a license to operate under or a recommendation to infringe any patent of DuPont or others.

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